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Animal Fibers Used in Brushes

By THORA M. PLITT HARDY, *microanalyst*, and JOHN I. HARDY, *animal fiber technologist, Animal Husbandry Division, Bureau of Animal Industry, Agricultural Research Administration*¹

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Brushes are an important commodity and have many uses. They cover a wide range of types from the ordinary floor sweeps to the finest artist's brushes. All brushes used in the Government service in considerable quantities are covered by Federal purchase specifications; there are over 40 such specifications. A large proportion of them are paint and varnish brushes made of hog bristles.² There are also many other brushes ranging from choice soft-hair brushes to the large street-cleaning brushes and brooms made from coarse vegetable fibers.

Soft-hair brushes are distinguished from bristle paint brushes by qualities which make them appropriate for more delicate jobs. They are used for sign lettering, decorations, and other art work. The fibers most generally used are from certain fur animals, such as squirrel, skunk, red sable, badger, and similar animals. Some brushes are made of the hair from goats and cattle.

How important soft fiber brushes are, and how necessary it is that they be made of specific fibers, was not realized until their scarcity became acute during World War II. In the spring of 1942 the industry decided at the Annual Convention of the American Brush Manufacturers' Association to cooperate closely with the Government.

¹ Valuable information and assistance were given by Isidor A. Rubin, Walter Grumbacher, and Jack Spector, brush manufacturers; and Walter K. Jones of the United States Tariff Commission.

² The section on paint brushes was furnished by the junior author.

The Fish and Wildlife Service³ undertook to seek supplementary and substitute fibers for soft-hair brushes. This work was carried on at the Agricultural Research Center, Beltsville, Md., from 1942 to 1944.

SOFT-HAIR BRUSH FIBERS

A brief survey of potential supplementary soft brush fibers was made by assembling a series of tufts of fur fibers which might become available if a demand for them arose. Included were fibers from the tails of American mink, ermine, marmot, and wolf. The rest were body fibers from the pelts of marmot, wolf, coyote, mountain lion, bobcat, opossum, spotted skunk, common skunk, muskrat, fur seal, rabbit, karakul, American goat, and a mixture of beaver and nutria guard hair waste fibers. Members of the brush trade inspected these tufts and pronounced the majority of the fibers unsuitable for use in brushes for various reasons—they were too short, too kinky, too soft, or too difficult to comb, and make up into bundles.

A number of brushes were made by cooperators from promising fibers (fig. 1). Hairs from American mink tails were made into artist's brushes (fig. 1, *A*) which were considered desirable as they are similar to fitch. But the fibers are so short that they are normally too difficult to dress in practice.

The hairs from skunk pelts were found to be desirable as they were better and finer than skunk-tail hair. Brushes made up from these fibers (fig. 1, *B* and *C*) were similar to civet brushes.

Hairs removed from a timber-wolf pelt were considered better than those taken from coyote pelts, even though they were similar in appearance. Such hair was made into brushes that could be used for bronzing and lacquering. Wolf hair also may be used in place of badger hair in shaving brushes and for textile stencil brushes (fig. 1, *D*).

Sample brushes of coyote hair (fig. 1, *E*) and of wolf hair (fig. 1, *F*) were made of 50 percent hair and 50 percent Chinese hog bristles to make them comparable with the commercial ox hair, skunk hair, and civet hair brushes. Such brushes are usually used in the application of varnish, lacquer, stains, or other materials that must be applied in a fine coat. These brushes were tried out by a finisher in varnishing and were all pronounced very good.

REQUIREMENTS AND CHARACTERISTICS OF THE FIBERS

The soft-brush trade has already pressed into use most of the available fibers that are suitable for soft-hair brushes (table 1). The requirements of fibers for these brushes are exacting.

³ Research activities pertaining to the production of the fur animals in captivity were transferred from the Department of the Interior to the United States Department of Agriculture on June 30, 1946, by act of Congress.



FIGURE 1.—Experimental brushes made of fibers as follows: A, American mink tail; B and C, skunk body hair; D, wolf body hair; E, coyote body hair and bristle; F, wolf body hair and bristle. Natural size.

TABLE 1.—List of commercial soft brush

Trade name of brushes	Animal supplying fiber	Scientific name of animal	Part of pelt	Raw-hair length (inches)	Amount of raw product required to supply 1 pound of finished hair	Finished
						Lengths (inches)
Badger	Badger	<i>Meles meles</i>	Body	2½ to 4	10 to 12 skins	2¾ to 3¾, 2¾ to 3¾, 2¾ to 3¾, 2¾ to 4, 3¾
"Camel Hair"	Squirrel	<i>Sciurus vulgaris</i> et al.	Tail	1¾ to 3	2½ to 3 pounds, or 300 tails.	1¾ to 3, 2 to 3, 2¼ to 3, 2½ to 3, 2¾ to 3.
Civet; "Black Sable."	Skunk, spotted.	<i>Spilogale putorius</i> et al.	do	2 to 3	5 to 6 pounds, or 150 tails.	2, 2¼, 2½, 2¾, 3.
Fitch	Fitch	<i>Mustela eversmanni</i> .	do			
"Fitch"; "Bear Hair."	Skunk	<i>Mephitis mephitis</i> et al.	do	4 to 5	5 to 6 pounds of tails.	4, 5.
"Genet"; "Civet Cat."	Ring-tailed cat.	<i>Bassariscus astutus</i> .	do			
Goat	Goat	<i>Capri hircus</i> et al.	Beard and body.	2½ to 9		2½ to 9
Ox Hair	Cattle	<i>Bos taurus</i>	Ear	1¾ to 5	50 ears taken in winter to 80 taken in summer.	1¾ to 3, 3¼ to 3¾, 4 to 5.
Pony	Pony	<i>Equus caballus</i>	Mane and body.	1¾ to 2	2 pounds of raw hair.	1¾ to 2
Red Sable; "Tartar Marten."	Mink (kolinsky).	<i>Mustela siberica</i> .	Tail	¾ to 2½	350 to 400 tails.	1½ to 1½, 1½ to 2¼.
Black Sable	Sable	<i>Martes zibellina</i> .	do			

The fibers must be of sufficient length that they can be handled by the dressers of soft hairs, because even though these men possess extraordinary skill, the fibers must be manageable. Because of their extreme shortness, the American mink tail hairs were dressed only with great difficulty. Furthermore, the short bundles could not be handled without breaking apart.

Strength of fibers is important because the consequent resistance to abrasion contributes to long life of the brush. Ox-ear hair and sable are noted for their strength; on the other hand "camel hair" is brittle, hence much less desirable. Skunk-tail hair, also, is brittle after the long boiling required to remove the odor.

The more resilient the fibers, the better the artist or painter is able to control the delivery of the fluid. Sable hair is remarkably resilient, but pony and goat hair are not.

The fibers should be straight or very nearly so in order that they may be properly alined in a tip. The accepted commercial hairs conform to this requirement (table 1). Both beaver and nutria hairs appeared to have desirable qualities for use in the making of soft-hair brushes but suitable samples were not obtainable at the time this study

fibers and data relating to each kind of fiber

hair				
Grades	Physical qualities	Kinds of brushes	Country or region of origin	Substitutes
Silver tip; Casings; Middles.	Strong and elastic; has greater tensile strength than any other soft hair.	Shaving, varnish, instrument, flowing and finishing brushes, and brushes for coating mills.	Turkey; U. S. S. R.; China; Macedonia; Balkans.	Bristles; skunk; horse-hair; ox hair; American badger.
Blue; Kazan...	Softest of all hairs employed in brush making; straight and fine in body, but not very elastic.	Color, flowing-varnish, artist's, lettering, lacquer, show-card, medical, dusting, and fine-instrument brushes.	U. S. S. R.; Canada.	Goat; pony; "genet"; American squirrel.
Black; Gray...	With fine points, smooth luster; fairly elastic.	Lettering, sign-writer's, fine-lacquering, varnishing, finishing, flowing, and railroad finishing brushes.	U. S. A.-----	Goat; skunk.
-----	-----	Artist's oil brushes-----	U. S. S. R.-----	-----
Black; Gray...	Coarser than civet; brittle.	Finishing and flowing brushes having bristles added to stiffen.	U. S. A.-----	Bristle mixed with goat.
-----	Soft; silky-----	Varnish and finishing brushes.	-----do-----	-----
White; Gray; Black.	Nonresilient; has tendency to mat; kinky.	Window-shade, twisted wire, lacquer, bronzing, facial, and inexpensive shaving brushes.	China; Thibet; Europe.	Pony (body).
Light; White; Red; Brown; Light-Red.	Most durable of all soft hair.	Varnish, finishing, lettering, show-card, and sign-writer's brushes.	Europe; U.S.A.; S. A.	-----
-----	Fine; limp; soft-----	Fingernail coating, watercolor, and inexpensive artist's brushes.	U.S.S.R.; Germany; Argentina et al.	Muskkrat.
Golden; Rich Yellow.	Strongest of all soft hair; of remarkable springiness and fineness; with finest and sharpest points of all hairs.	Fine-instrument, watercolor, oil-painting, show-card, medical, fine-lettering, striping, lipstick, and high-quality artist's brushes.	U. S. S. R.-----	Mink; ox hair; fitch.
-----	Straight; elastic; uniform in taper; splendid points.	Finest lettering and striping brushes.	-----do-----	-----

was made. Beaver hair has been used to some extent for brushes and is mentioned by Schlott (?).⁴ Marmot hairs and wolf-tail hairs were not suitable because of their kinkiness. Likewise, American goat hair proved too "woolly" for paint brushes. Bear hair, formerly utilized by the trade, was strong but kinky and it had to be blended with other fibers to make it suitable for brushes.

Fineness of the fibers is highly desirable for certain types of brushes because the more exacting the work to be done, the finer must be the tools. The hair of red sable (kolinsky), an Asiatic mink, has very fine fibers with long fine points; this type of fiber gives the best control of the delivery of paint. True sable hair is used exclusively in the best quality artist's and lettering brushes as the fibers in these brushes are so arranged that the whole brush comes to a fine tip.

The diameters of individual fibers of soft-hair brushes vary from one end to the other. Starting with the diameter near the root end of the hair, the diameter usually increases for about two-thirds to three-quarters of the length of the fiber to a maximum diameter. After

⁴ Italic numbers in parentheses refer to Literature Cited, p. 15.

that the fiber tapers to a point. Brief consideration of the many ways in which these relative diameters can vary leads to an understanding of why so few hairs are suitable for brushes. Frequently the increase to the maximum diameter is too rapid, or the taper to the point too sudden, causing the shape of the brush to be uneven and the ends to flare; consequently, the paint cannot be delivered properly. In other words, the most suitable fibers for soft-hair brushes increase in diameter slightly, gradually, and uniformly to the thickest part and then taper off again gradually and uniformly to a long fine point.

Other characteristics of the fibers are revealed by the microscope. It will be noted from the cross sections of soft-brush and paint-brush fibers shown in figure 2 that there is variation in the diameter and shape of the individual fibers themselves. Microscopic measurements, however, assist in the evaluation of the fineness of these fibers and in the determination of their degree of uniformity. Cross sections are also used to obtain information concerning the distribution of pigment and the proportions of cuticle, cortex, and medulla (outermost, middle, and innermost parts) of the hairs.

The fibers in a brush intended for a certain purpose must be resistant to the action of the substances used, such as varnish, lacquer, or oil. For instance, although wolf hair will stand exposure to water, coyote hair becomes wrinkled and is therefore undesirable for artist's brushes. Even appearance adds to the value of a brush. "Silver tip," a high grade of badger, is handsome but rare, and for this reason brings a premium. Similarly, Kazan squirrel has a light golden stripe below the tip which is attractive and cannot be imitated. Therefore "camel hair" brushes made of these fibers bring a higher price because of their appearance.

SOFT-BRUSH FIBERS IN COMMERCE

The fibers possessing the necessary qualities to make them suitable for use in brushes for fine work are scarce in nature. The lack of even one of the desirable characteristics mentioned above decreases the desirability of a material. Furthermore, there must be a fairly steady supply available. For this reason most of the fibers utilized in making brushes are a byproduct of the fur industry (4), usually taken from the tails of fur animals because the tails are not customarily used in making up coats or jackets. However, brushes may be made from scraps and unprime pelts from predators taken out of season, or pelts of poor quality.

Not only are there differences between brushes owing to the kinds of animals from which the fibers come, but also there are various grades within the same types of brushes. Thus a distinction is made between eastern skunk hair which is of the best quality, and the hair of northern and western skunks. Likewise four different qualities of squirrel hair for "camel hair" brushes are recognized: Saccamina, or blue; Kazan; Talaoutky (Talahutky), or gray; and blended. The grades are associated with geographic regions; undoubtedly the fibers collected in different regions are obtained predominantly from different subspecies. The various effects of geographic regions are described by Brass (1) in reports on the fur trade.

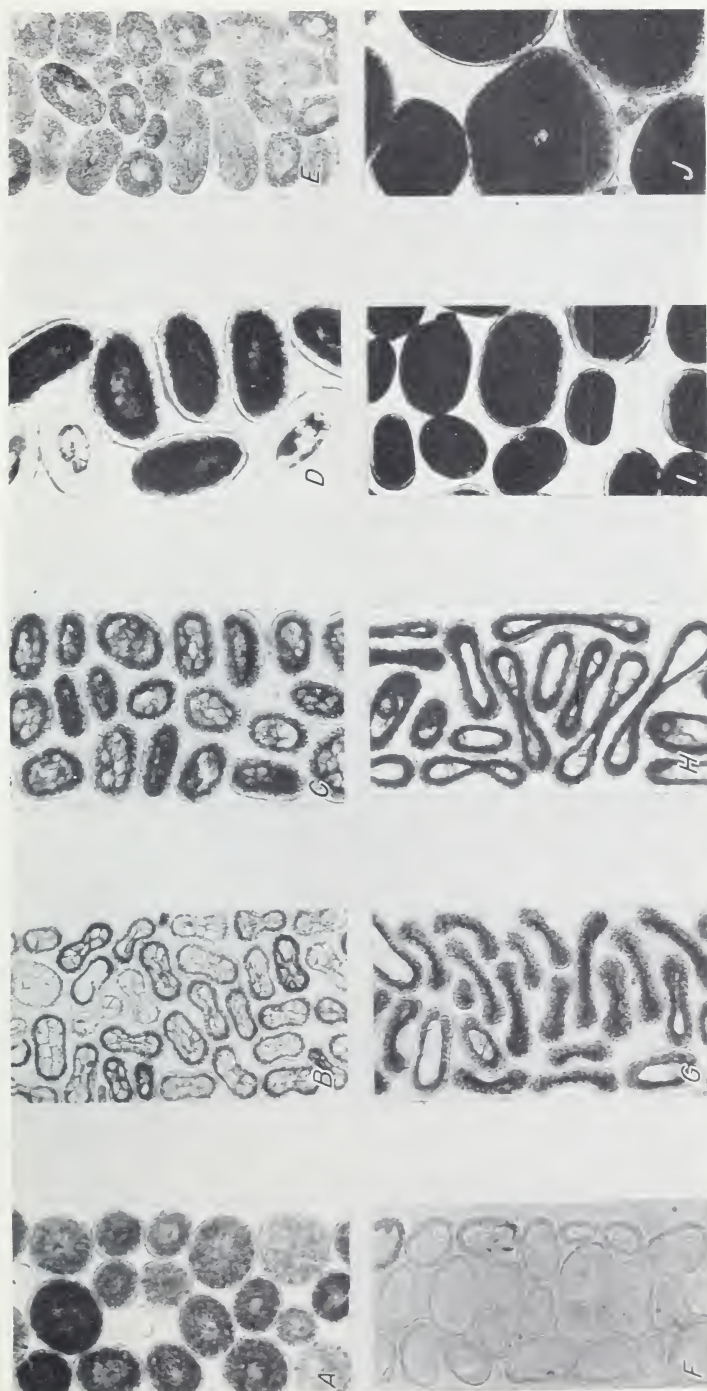


FIGURE 2.—Cross sections of eight kinds of soft-brush fibers, magnified 200 X, and two kinds of paint-brush fibers (Chinese hog bristles), magnified 100 X: A, Ox-eur hair; B, Saccamima squirrel; C, civet; D, badger; E, goat; F, pony; G, eastern skunk; H, western skunk; I, Tientsin bristles; J, Chumking bristles. Photographed by Ethel H. Dolnick.

Another consideration is the amount of fiber that can be recovered from the raw material in dressing (table 1). The underfur of all animals is too soft for brush making. In the coyote pelts only the guard hair from the center of the back was removed for making the experimental brush. The yield of suitable fibers may be only about 2 ounces of usable hair from five coyote skins. The timber wolf skin, on the other hand, may yield $1\frac{5}{8}$ ounces of hair suitable for making good soft brushes.

Fibers used in shaving brushes must be sterilized to prevent the transmission of disease, particularly anthrax. Badger hair and hog bristles are treated with steam, under pressure, at 120° to 121° C. for 25 minutes. Horsehair $2\frac{1}{2}$ inches long is treated in the same manner. Longer hair requires 30 minutes under pressure. The United States Public Health Service has carried on research on conditions under which fibers may be boiled or treated with steam so that the fibers will be sterile and yet suffer a minimum of damage (8).

PAINT BRUSH FIBERS

CHARACTERISTICS OF THE BRISTLES

Bristles are the stiff hairs or fibers obtained from pigs and, in most cases, are taken from along the backbone, the best quality being those over the shoulders. Hogs are the only animals that produce bristles in commercial quantity. Domesticated hogs of foreign countries, where breeding stock is kept to an older age, produce the best bristles (table 2). Comparatively few useful bristles are gathered from wild boars.

TABLE 2. *Types of commercial paint-brush fibers and their characteristics*

Trade name	Fibers	Fiber length (inches)	Grade	Color	Physical characteristics	Kinds of brushes
Russian	Hog bristles	2½ to 9	Stiff; half-stiff	White; yellow; gray	Heavy and coarse in texture; little taper; heavy flag.	Calamine and skimming brushes; special machine brushes; dusters and sweeps.
North China	do	2 to 8	Tientsin, soft; Manchurian, soft; Mukden, soft; Tsingtau, soft.	Black	Smaller in diameter and with finer flag than other types of Chinese and Russian bristles.	Flat varnish and paint brushes.
South China	do	2 to 8	Chungking, stiff; Yunnan, stiff; Hankow, half-stiff; Shanghai, soft.	do	Stiff; little taper; heavy flag	Paint, machine and mill, scrub, furniture and rubbing brushes.
White China	do	2 to 6	White Chungking; White Hankow.	White	Stiff	Tooth brushes and hand scrubs.
India	do	3 to 9	Soft	Black, gray	Harsh in texture; stiff; tapering from a heavy butt to a ragged flag.	Hair, nail, and industrial brushes.
White French	do	Short	(Fine droites) Superior Beau-Blanc Beau-Blanc Demi-Blanc	White White "White" (light-yellow) "White" (dark-yellow)	{ Fine; straight	Artist's, cutter's, varnish, and toilet brushes.
Polish	do	2 to 6	Stiff	Yellow; "white" (gray)	Similar to Russian bristles; good taper; good flag.	Varnish, paint, tooth, and toilet brushes.
German	do	2 to 6	Medium	Black	Medium	Artist's, varnish, and toilet brushes.
U. S. Domestic	do	2½ to 3½		Reddish-gray mixture	Strong flag; similar to Russian bristles.	Varnish, sash-tool, and enameling brushes.
Horseshair	Hair from tail and mane.	4 to 36	Tail; mane	White; light-gray; dark-gray.	No flag, or artificially flagged	Cheap paint brushes for rough work; sweeps; painter and counter dusters; bottle and sanitary machine brushes.

The length of bristles ranges from 2 to 9 inches, depending upon their origin. Bristles taken from hogs in the United States range from $2\frac{1}{4}$ to $4\frac{1}{4}$ inches in length. The brushes with the longest bristles are the highest priced as they are the most desirable. Long bristles, however, are scarce and as bristles are sold by weight there are fewer long bristles to the pound.

Bristles are thick at the butt or root end and gradually taper to the tip. This taper contributes to the resiliency of a brush, an important property in controlling delivery of paint to a surface. The surface of

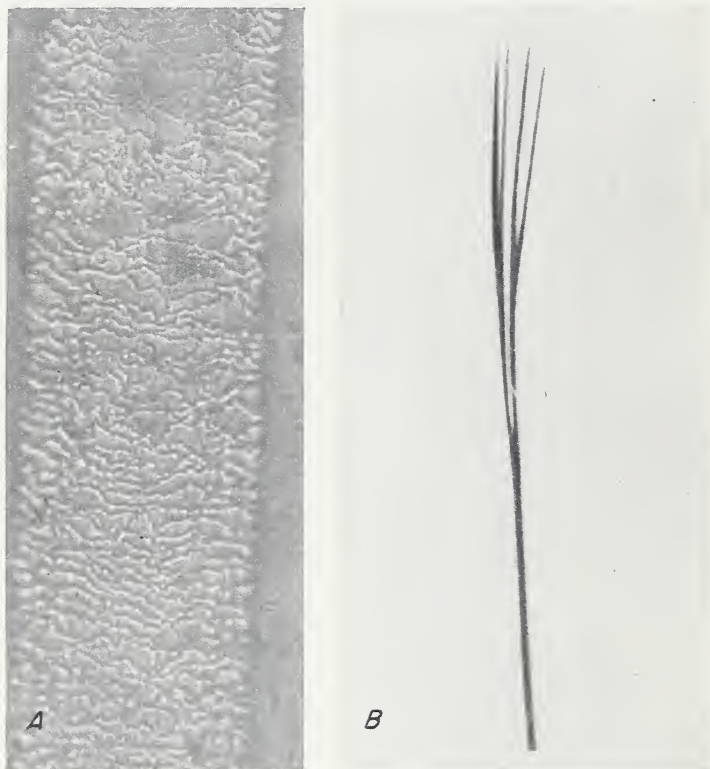


FIGURE 3.—Chungking bristle: A, Typical surface structure, greatly magnified; B, flag at the tip end of the bristle, magnified approximately 8 X.

a bristle has a scalar structure (fig. 3, A) which tends to hold paint in the brush until properly applied. This holding power of bristles and also the softness of the tip of the brush is further increased by the split tip, or flag, which usually consists of two, three, or four ends (fig. 3, B). The resiliency, the scalar surface, and the flag end of bristles combine to control the flow of paint, which is necessary to produce a smoothly decorated surface.

The skill with which a brush is made is important. The raw bristles, as they are called, are curved, following the contour of the body of the animal. Bristles to be dressed are placed in perforated metal cones which hold the fibers straight. While in these cones the fibers

are boiled and practically straightened. The shaping of a brush, which is one of the many steps in dressing, is particularly important in facilitating the proper delivery of paint. The "chisel," or taper, is made by a calculated blending of shorter with longer fibers. Furthermore, expert craftsmanship is required in turning the bristles in such a way that whatever slight bend is still in them will bring the tips of the fibers toward each other at the tip of the brush.

MACHINE FOR TESTING TAPER OF BRUSHES

A machine for testing the chisel, or taper, of brushes (fig. 4) was developed by the junior author. A slotted frame (*A*) was set vertically to guide a metal straightedge (*B*), to which a fixed weight (*W*)

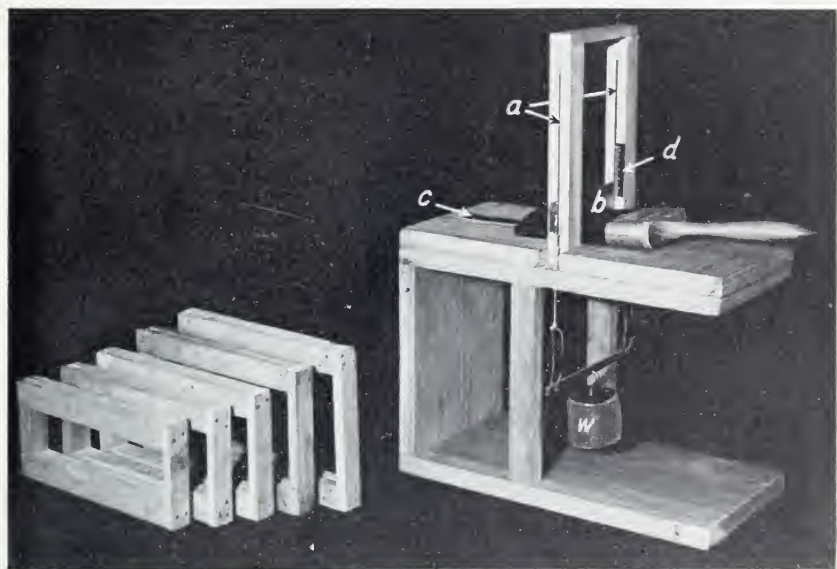


FIGURE 4.—Testing apparatus for measuring the chisel of paint brushes. *A*, Slotted frame to guide straightedge *B*. *C*, Scale to measure length of bristles. *D*, Scale to measure thickness of brush. *W*, Weight attached to straightedge. As each measurement of the thickness of the brush is made, the brush is moved 1 centimeter to the right for another measurement. Five extra frames of different sizes are shown at the left.

of 1,260 grams ($2\frac{3}{4}$ pounds) was attached in such a way as to distribute the weight uniformly across the brush. Frames of various widths to fit different brushes were used so that the bristles on the edges of the brushes of different widths were held in approximately their original lines. A metric rule was fastened on the horizontal face of the machine with the zero reading at the straightedge to measure the length of bristles. Another metric rule was fastened to the vertical frame with the zero reading at the horizontal face to measure the thickness of the brush.

To make the thickness measurements, the brush was laid flat on the horizontal face. The weighted straightedge was placed on the brush

TABLE 3.—*Chisel, or taper, of brushes measured with the testing machine*

Brush	Thickness at the following lengths from bristle ends—									Total length of fibers	Fiber mixture
	9 cm.	8 cm.	7 cm.	6 cm.	5 cm.	4 cm.	3 cm.	2 cm.	1 cm.		
A-----	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	<i>Cm.</i>	50 percent yellow, half-stiff Russian and 50 percent Chungking. 25 percent bristle and 75 percent horsehair.
B-----	2.5	2.3	2.2	2.1	2.0	2.0	1.8	1.4	1.1	10.4	

at the edge of the ferrule and the first measurement, or thickness, was noted on the vertical scale (*D*). The brush was moved back at 1-centimeter intervals, the weighted straight edge was then lowered, and the thickness recorded as shown in table 3. These measurements are also shown graphically in figure 5. The uniform chisel of brush *A* is easily recognized as more desirable than the uneven chisel of brush *B*.

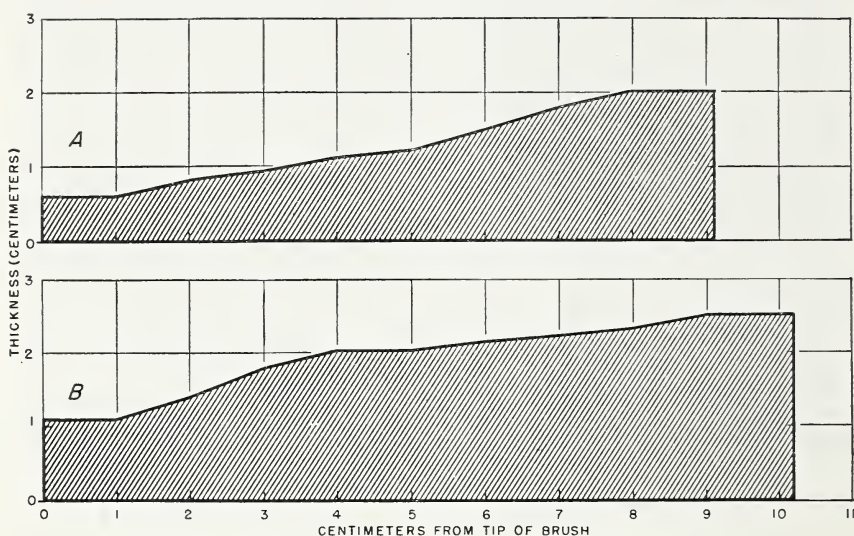


FIGURE 5.—Chisel, or taper, of brushes A and B, shown graphically according to measurements taken with apparatus shown in figure 4.

CONSERVATION OF PAINT BRUSHES

An understanding of the fine qualities of the fibers and an appreciation of the workmanship embodied in good brushes should aid painters to take better care of their brushes and make them last longer (5, 10). Brushes should be treated the same as any precision tools that must be kept in first class condition to give satisfactory service. Some brushes must be "broken in" before using (6). Thus, a new brush intended for use with oil paint should first be immersed in linseed oil for 12 hours. After removal of the excess linseed oil, the brush is dipped slowly into the paint until it takes up a sufficient amount. Paint is applied to a surface with the flag end and one-half of the length of the bristle only.

A wire across the top of the paint pot for removing excess paint after each dip of the brush, helps keep the brush straight; otherwise the mouth of the pot bends the bristles out of shape at the edges of the brush.

The proper-sized brush should be used for each job so that the flag ends of the bristles will be worn uniformly (2). Thus a wide brush used to apply paint to pipes results in "fish tailing" or wearing down the center of the brush at the tip. Use of a wide brush edgewise on narrow trim causes "lingering" or bristles gathered into small bunches. Poking a brush into corners pushes the bristles out of place; thereafter the brush can no longer deliver paint smoothly on a flat surface. Rough surfaces wear down brushes rapidly, hence it is good practice to use an old brush while applying the first and second coats of paint.

Of equal importance, but often neglected, is the proper and prompt cleaning of brushes. At the end of each day's work the brush should receive attention. The brush should be cleaned with the proper fluid, such as turpentine if paint, enamel, or varnish was used, or alcohol if shellac or alcohol stain was used. Lacquer thinner is used for cleaning after applying lacquer. The brush can then be hung overnight in linseed oil if it was used with oil paint. A brush should be suspended in the oil when not in use, because if allowed to rest on the flag end the tips will curl and the brush will be damaged. Before a brush is stored after the completion of a job, all the paint or other substance must be thoroughly removed from it. The fibers must be clean all the way up to the ferrule or metal band and then properly aligned with a comb, and dried. The brush may then be wrapped in heavy paper which should be folded like the original wrapper to keep the fibers in place. The brush can then either be hung up or laid on one side. If the brush is not likely to be used for some time, put it in a tight container with moth balls or paradichlorobenzene to keep destructive insects out.

A neglected, hardened brush usually can be restored to usefulness by first soaking it in turpentine or a commercial brush cleaner for a day or even two to soften the paint. Then work the accumulated paint loose with a scraper, operating from the heel of the brush to the tip. Wash the brush in hot water and neutral soap and rub it back and forth on a board, or even better, on an old-type washboard, pressing down firmly to clean thoroughly. Afterward, rinse the brush repeatedly in clear water. Comb the bristles to bring them back into position. Wrap the brush in heavy paper, and hang it up to dry. Some manufacturers of brushes advise dipping the brush, when dry, in linseed oil, rewrapping, and then storing as described above.

SOURCES, DRESSING, AND GRADES

Bristles come from Europe and Asia. Russia and China (3) are the chief sources of supply, although some come from India, France, Germany, and other countries where hogs are kept to an older age than is the custom in the United States. American pigs have been improved for the production of pork and have been considered unsuitable for the production of bristles, although excellent bristles of the shorter lengths were obtained during the war. However, they were obtained at too high a cost to be practical in normal times.

Bristles are dressed and graded in several different colors, grades, and degrees of stiffness before they are marketed. The most common color is black, though others are white, gray, yellow, and bronze.

The dressing process calls for a careful washing before they are packed for shipment. The next step is to place the bristles of various lengths into bundles. They are then "dragged" through special combs to obtain the desired fineness, the spacing between the teeth of the comb being the proper width to hold the coarser fibers. Dragging also takes out short irregular fibers and foreign material. This process is carried out in the country of origin.

Russian bristles are dressed in two different grades of stiffness—stiff and half-stiff. They come in three colors: white, yellow, and gray, in each length. They are packed according to grade and color and sold separately. Chinese bristles are sold in two classes, northern (9) and southern, with names usually corresponding to the name of the city or port of collection.

The principal northern bristles are Tientsin bristles (fig. 3 *A*) which are soft and well suited to the manufacture of varnish brushes. The Manchurian and Mukden bristles, also classed as northern, are somewhat better than the Tientsin bristles. On the other hand, the northern Tsingtau bristles are not quite so good as Tientsin bristles but are accepted as substitutes.

Southern China bristles are stiffer and heavier than the northern bristles. The chief kinds are Chungking (fig. 5, *B* and *C*), Yunnan, Hankow, and Shanghai. Hankow bristles are used principally for paint brushes. The Chungking, Shanghai, and Yunnan bristles are used in machine or mill brushes. Chinese bristles are predominantly black, but white bristles are produced in both northern and southern China. The southern white bristles are generally called white Chungking and white Hankow, and are used in toilet brushes.

India bristles are generally black; however, some are gray in color. These bristles are heavy, wiry, and tough, with a rough flag end. They are used to stiffen other blends.

French bristles are the best of the white bristles. They are well adapted to the tooth-brush and toilet-brush trade. Many of these are said to originate in China.

SUBSTITUTES AND SUPPLEMENTS

During the war there were extreme shortages of bristles. War Production Form WPB 547 restricted paint brushes to 55 percent bristles and 45 percent horsehair. This order made mandatory the use of 45 percent horsehair in all paint brushes. This was a means of extending the use of bristles and made it possible to carry on with the available supplies during the war. Horsehair ends are sometimes split to simulate the flag ends of bristles, but the process adds greatly to the cost of the finished brushes.

Nylon brushes are used extensively and successfully by many painters and when fully broken in they are said to work as well as the best pure-bristle brushes. They have excellent wearing quality. Nylon fibers are tapered, but do not have flag ends. To increase their holding power of paint, the surface is roughened in simulation of the scales of bristles.

Bristles from domestic pigs are usually from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches in length, with a small percentage measuring $3\frac{3}{4}$ inches. These are excellent bristles of greater strength than foreign bristles and are obtained from Duroc, Chester White, Berkshire, and Poland China hogs. Their quality ranks in the same order as listed and are all blended into one reddish-gray mixture. Domestic bristles were successfully collected during the period of high-priced bristles, but the practice was discontinued when prices dropped.

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